Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of	)	
	)	
Use of Spectrum Bands Above 24 GHz For Mobile Radio Services	)	GN Docket No. 14-177
	)	
	)	
Establishing a More Flexible Framework to Facilitate Satellite Operations in the 27.5-28.35 GHz and 37.5-40 GHz Bands	)	IB Docket No. 15-256
	)	
	)	
Allocation and Designation of Spectrum for Fixed-Satellite Services in the 37.5-38.5 GHz, 40.5-41.5 GHz and 48.2-50.2 GHz Frequency Bands; Allocation of Spectrum to Upgrade Fixed and Mobile Allocations in the 40.5-42.5 GHz Frequency Band; Allocation of Spectrum in the 46.9-47.0 GHz Frequency Band for Wireless Services; and Allocation of Spectrum in the 37.0-38.0 GHz and 40.0-40.5 GHz for Government Operations	)	IB Docket No. 97-95
	)	
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	)	
	)	
	)	
Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service Rules for the 42.0-43.5 GHz Band	)	RM-11664
	)	

REPLY OF THE EMEA SATELLITE OPERATORS ASSOCIATION (ESOA)

The EMEA Satellite Operators Association ("ESOA") submits these reply comments in response to the Federal Communications Commission's ("FCC") Notice of Proposed Rulemaking ("NPRM") in the above referenced proceeding.

I. Identification of suitable bands for 5G.

After reviewing the record to date, ESOA bases its reply comments on three main principles: (1) international harmonization as a key for the success of future 5G systems roll out; (2) the need to ensure incumbent services are not displaced and allowed to expand their services in the future; and (3) the suitability of the band 31.8-33.4 GHz and 64-71 GHz for future mobile services. Accordingly, ESOA urges the FCC to move forward with a rulemaking proceeding based on the above key principles to determine the use of the frequency bands above 24 GHz. In doing so, ESOA is of the view that the FCC can provide the appropriate balance between enabling new 5G services and allowing for continued investment and innovation in existing services (particularly the 28 GHz band).

II. International Harmonization

In its NPRM, the FCC identified international harmonization as one of the four main criteria to be used in evaluating the suitability of mmW bands for mobile use. In addition, they stated they would "*work with other countries through the International Telecommunications Union (ITU), in particular the World Radio Conference (WRC), and other processes to promote harmonized spectrum assignments for mmW mobile use*"[1]. ESOA commended the FCC for these statements in its Comments to the NPRM and recognized the importance of the future requirements for globally harmonized spectrum for IMT services in relevant frequency bands above 24 GHz.

Numerous commenters, including AT&T, 4G Americas, Samsung and Huawei highlight the benefits of globally harmonized spectrum bands for future terrestrial 5G services in their comments to the NPRM. Cisco, in particular, states that "*for technology companies to make the substantial investments necessary for developing 5G equipment, the Commission must (1) provide reasonable assurance that the market for mmW-based mobile*

[1] *See Use of Spectrum Bands Above 24 GHz For Mobile Radio Services*, GN Docket No. 14-177, et al., Notice of Proposed Rulemaking, FCC 15-138, 30 FCC Rcd. 11,878 (2015) ("NPRM").

services will be large enough to justify those investments"[2] Specifically, global harmonization benefits include (1) global interconnection (the economies and scale); (2) limit the number of models of equipment needed; (3) better roaming cost; (4) minimising fragmentation of spectrum; and (5) greater interoperability.

As ESOA noted in its original comments, the ITU Member States attending the WRC-15 chose not to include the band 27.5 - 28.35 GHz ("the 28 GHz band") for terrestrial mobile service ("MS") in studies planned for WRC-19. Given the importance of international harmonization and the outcome of the WRC-15, ESOA urges the FCC to consider the suitability of the 32 GHz band for the future development of 5G services as an alternative to the 28 GHz band. ESOA is of the opinion that continuing to consider the 28 GHz band would risk delaying the rollout of 5G services in the United States and worldwide, as the band does not have broad international support for future IMT/5G use and will therefore not achieve consensus during the development stage of IMT, let alone international harmonization.

III. Elevate FSS Earth Stations to Co-Primary Status

In its review of the comments, ESOA notes the significant support for the elevation of the FSS from secondary to co-primary status in the frequency band 27.5-28.35 GHz. Viasat, Boeing, SES, EchoStar, Inmarsat, O3b, Avanti and SIA are all in agreement as to the valuable use that is made by the FSS in this band and that such use should be allowed to continue with an opportunity to grow in the future with regulatory certainty provided by co-primary licensing status.[3] Multiple applications, such as broadband by satellite, are enabled by earth stations operating in this band and which have to date shared well with the co-frequency LMDS deployment. To protect these existing deployments and to allow similar types of

[2] http://apps.fcc.gov/ecfs/comment/view?id=60001386426 *(see page 4)*
[3] See http://apps.fcc.gov/ecfs/proceeding/view?name=14-177 (Viasat/ Boeing/ SES/ EchoStar/ Inmarsat/ O3b/ Avanti/ SIA comments to FCC)

deployment to continue to occur, the FCC should take advantage of this rule making to elevate the status of the FSS from secondary to co-primary status within the 28 GHz band.

Furthermore, ESOA has conducted a technical assessment and believes there is a risk that 5G base and mobile stations could cause harmful interference into on-orbit satellite receive antennas (see Annex attachment).[4] FSS has been able to coexist with FS in the 28 GHz band because FSS earth stations have been sited so as not to cause interference with existing FS links. The use cases and deployment scenarios of fixed LMDS links are well known. But as the NOI comments and the NPRM reflect, what "5G" mobile services will look like is speculative at this point, and any actual deployment is years in the future. ESOA encourages the Commission to consider this potential risk to satellites in designing mobile operating requirements.

ESOA's technical assessment is an illustration of one possible scenario. If mobile services are introduced in the 28 GHz band, other likely scenarios must be considered and addressed in final operating rules. Given the lack of information about the topography, scope, scale, and other conditions of possible mobile operations, the record is not sufficiently complete to permit the FCC to address those issues at this time. Before the FCC authorizes terrestrial mobile services at 28 GHz it should, establish a process in which the issues can be examined, understood and addressed in workable operating rules. That process should include a further notice of proposed rulemaking, and the FCC should encourage affected stakeholders to propose a consensus solution.

[4] ESOA's annexed analysis concludes that sharing the 27.5-28.35 GHz frequency band between IMT 5G networks and satellite systems under the parameters proposed by the FCC could result in significant harmful interference to satellites. It is found that the aggregate interference from IMT base stations deployed in New York alone will exceed the interference threshold of Inmarsat's Global Xpress satellite by 1.34 dB. The matter is even more concerning when interference from multiple densely populated cities and its surrounding areas within the satellite's spot-beam are taken into consideration. As a result, the Commission should carefully study the interference into satellites operating in the 28 GHz band before proceeding with this portion of the rulemaking. Based on ESOA's calculations, in order to reduce the potential interference to satellites, the allowed spectral density for 5G terrestrial stations in the 28 GHz range should be significantly lowered. As this may result in overly restricted criteria for IMT 5G operation that may reduce the key benefits of the technology, it may be wiser to restrict stations to indoor operation, where much higher emission values can be used.

IV. Suitability of the 32 GHz band

ESOA commends the FCC for opening consideration to the 31.8 – 33.4 GHz band (the "32 GHz band") as a suitable candidate for IMT services.[5] This band gathered international support during WRC-15 and will therefore be considered within the ITU framework for sharing and compatibility studies in support of a possible new allocation and identification for future terrestrial 5G services at WRC-19. Even after excluding the 33.0 – 33.4 GHz band currently used for Federal satellite systems under US FN G117, the band still provides 1.2 GHz of spectrum. This is twice as much spectrum as that available in the 28 GHz band, with similar propagation characteristics and a higher likelihood of international harmonisation.

Several mobile terrestrial 5G proponents have also identified this band as a good candidate for terrestrial 5G services. In particular, Samsung – a pioneer in the development of 5G trials in the United States – expressed its support for future spectrum identification at 32 GHz for mobile services.[6] In addition, and considering the outcome of the WRC-15, Nokia and T-Mobile also asked the FCC to consider the 32 GHz band in the proceeding.

Furthermore for the ambitious bandwidth needs set out for 5G, the higher frequencies such as the 32 GHz can offer more opportunities. The very high user data rates anticipated by 5G deployments require substantial system capacity (consider the amount of overall system capacity required to support millions of users with peak data rates of 1 Gbps or even more). A spectrum efficient deployment of such networks requires maximizing the frequency reuse factor, which increases with the carrier frequency as the user range decreases due to physics of signal propagation. Going to higher carrier frequencies is in this respect an advantage rather than a drawback. It is also expected that use of the 32 GHz will rely

[5] http://apps.fcc.gov/ecfs/comment/confirm?confirmation=2016127522505
[6] http://apps.fcc.gov/ecfs/document/view?id=60001414286 (see page 16)

primarily on line-of-sight paths at ranges in the order of 100 –200m or less. Research has indicated that massive MIMO can provide additional benefits, which can be exploited more effectively as the carrier frequency increases.[7]

V. Suitability of the 64-71 GHz band

Provided that the bands considered in the NPRM aim to fulfil future terrestrial 5G services' requirements for capacity, ESOA believes that the 64-71 GHz band should also be prioritized. The FCC should grant exclusive use to mobile services within the 64-71 GHz band to ensure the spectrum can efficiently be put to use supporting 5G systems, and promote economies of scale and globally accessible services. The importance of this band is clear in the comments filed by mobile industry – manufacturers such as Ericsson, Nokia, Intel, Qualcomm and operators such as T-Mobile or AT&T all support allowing mobile services in the band.[8]

Furthermore this band is well suited for indoor home licensed 5G services. Microwave links can co-exist with unlicensed short range broadband mobile broadband access technologies like WiGig which are today available in the market. But more importantly it is the specific propagation conditions in this band (characterized by a maximum oxygen absorption in the 60 GHz band) that can facilitate coexistence which is expected to be feasible without implementation of any mitigation technique.

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[7] The University of Texas, Austin (http://users.ece.utexas.edu/~rheath/presentations/2015/ComparingMassiveMIMOSub6GHzAndMmWaveICC2015Heath.pdf)

[8] See FCC NPRM comments. [The FCC will expect you to provide specific citations to each set of comments and the specific pages that reference the point you are making. I recommend you look at how SIA cited documents in its initial comments.]

VI. CONCLUSION

ESOA urges the FCC to ensure that U.S. consumers and organizations continue to have access to cost-effective, innovative and spectrally efficient satellite services through the elevation of the FSS from secondary to co-primary status within the LMDS 28 GHz band. In addition, we recommend that the FCC actively promotes the inclusion of the 32 GHz and the 64-71 GHz band for future IMT / 5G mobile use in the US, given its high prospects of global harmonisation for 5G mobile broadband. These bands could be preferable alternatives to the 28 GHz band for new mobile services.

Respectfully submitted,

ESOA

/s/ Aarti Holla
Aarti Holla
Secretary General
ESOA

February 26th, 2016

ANNEX

POTENTIAL INTERFERENCE FROM 5G SYSTEMS TO SATELLITE UPLINKS IN THE BAND 27.5-28.35 GHZ

1. Description of the study

The following study considers the interference from potential base station IMT 5G deployments into the uplink of Inmarsat's Global Xpress satellite in the 27.5-28.35 GHz band. The characteristics of the IMT 5G network are based on the operational limits suggested by the FCC in its *Notice of Proposed Rulemaking*[9] *("NPRM")* and the values indicated by the IMT 5G proponents. The main reference for the IMT deployment characteristics used in this study are Straight Path's comments[10] ("*Straight Path's comments")* as it provides detailed insight to the 5G network link budgets and operational parameters base stations. In addition, reference is also made to comments of Nokia[11] ("*Nokia's comments"*), Verizon[12] ("*Verizon's comments"*) and Huawei[13] (*"Huawei's comments")*.

The Commission anticipates[14] that usage of frequency bands above 24 GHz for mobile deployments would initially take place in highly localized areas with high demand for mobile capacity. For this purpose, we have selected the City of New York, as one of the most densely populated areas in the world, for the assumed IMT 5G deployment. The choice is also appropriate, since some information on the deployment geometry of IMT 5G networks in New York is already available. Namely, NYU wireless – a research centre – has studied[15] ("*NYU Study"*) the coverage of the 28 GHz band in down-town Manhattan and Brooklyn over the years 2011-2013. The results of the *"NYU Study"* indicate that micro urban IMT deployments with a cell radius of 200 m in the 28 GHz band are achievable using a 7 m high base station antenna. These parameters also align with *"Nokia's comments"* and *"Huawei's comments"* which suggest a base station height in the range of 6-10 m and cell radius of 100-400 m.[16]

Further information on the operational characteristics of 5G networks in the City of New York can be extracted from "*Straight Path's comments"*, which propose the link budgets for both up - and downlink of outdoor 5G cells in 39 GHz[17]. It can be considered that these

9 *See In the Matter of the Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, et al.,* GN Docket Nos. *14-177, Notice of Proposed Rulemaking (rel. October 23, 2015) ("NPRM")*

10 Comments of Straight Path Communications, Inc., GN Docket No. 14-177, RM-11664 (filed Feb. 16, 2016) (*"Straight Path comments")*

11 Comments of Nokia, GN Docket No. 14-177, RM-11664 (filed Feb. 05, 2016) (*"Nokia comments")*

12 Comments of Verizon, GN Docket No. 14-177, RM-11664 (filed Jan. 28, 2016) (*"Verizon's Comments")*

13 Comments of Huawei Technologies, Inc et al, GN Docket No. 14-177, RM-11664 (filed Jan. 29, 2016) (*"Huawei comments"*)

14 *See "NPRM" at ¶* 212

15 *See IEEE VOL 63, No. 9, September 2015: "Wideband Millimeter-Wave Propagation Measurements and Channel Models for Future Wireless communication System Design"*

16*See page 12 and 14 in "Huawei comments" and page 33 of "Nokia comments"*

17 *See "Straight Path's comments" page A-1*

parameters would be very similar for the base stations in the 28 GHz and are therefore appropriate for this study.

The study assumes complete coverage of the City of New York by base stations using the cell size and antenna height specified in the "*NYU Study"* and the operational characteristics specified in the *"NPRM"* as well as documents submitted in response to the *"NPRM"* by the IMT proponents. The victim of interference emitted from the assumed IMT 5G deployment is considered to be Inmarsat's I5-F2 Global Xpress satellite, located at an orbital location of 55° W. The study assumes that the satellite's uplink beam operating in the 27.5-28.35 GHz band is covering the city.

In order to assess interference from a high-density urban area, effects of the surrounding clutter on the interfering IMT signals should be assessed. Assuming a 7 m IMT base station height, the elevation angle of the station towards the satellite in the target area would be 39°. Recommendation ITU-R P.452 suggests that a distance of 20 m should be considered between surrounding clutter and the transmitter in an urban environment. Therefore, by means of basic geometry, it can be shown that a building height of 23.2 m would be required to obstruct the line-of-sight between the satellite and the IMT base station. Consequently, it can be concluded that any buildings below 23.2 m in height would not obstruct the interfering IMT signal and clutter loss would be negligible.

As New York contains some of the World's tallest skyscrapers, it is evident that there are areas in the city where the 23.2 m building height can be exceeded. However, a detailed assessment of the resulting clutter loss would require vast amounts of information on building heights. Due to the unavailability of this information, data from the United States Census Bureau[18] on the number housing units in a single building is used in the study. A housing unit is defined as the area where its occupants are separated from any other individuals in the building. The number of housing units would therefore give an indication of the size of the building. For example, in high-rise urban locations such as Midtown Manhattan, the number of buildings containing 1-9 housing units is just 7% and the remaining 93% are buildings that contain 10 or more housing units. In comparison to the Charleston neighbourhood in New York, which is a low-rise suburban area, only 3% of the buildings have 10 or more housing units. The study assumes that all buildings with up to 9 housing units correspond to the 20 m building height specified for the *urban* clutter scenario in Recommendation ITU-R P.452. Consequently, for buildings that have 10 or more housing units, the *dense urban* scenario from the same Recommendation applies, which specifies a 25 m building height. It can therefore be concluded based on the IMT base station height and look angle towards the Inmarsat satellite that for any buildings with up to 9 housing units, clutter loss is negligible, and for buildings with 10 or more housing units, clutter loss would need to be considered as the line-of-sight between the IMT base station and satellite is obstructed.

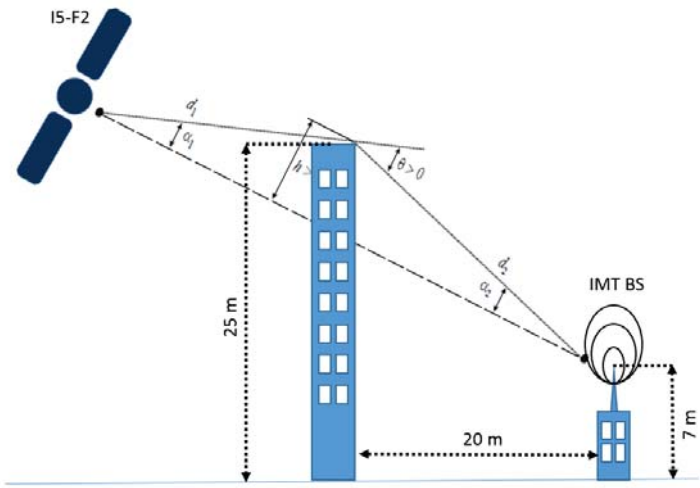
In order to determine the magnitude of the clutter loss however, a different method from the procedures specified in ITU-R P.452 is required. Since ITU-R P.452 is intended for

18 *Available from*: http://www.census.gov/

evaluation of clutter loss on the surface of the earth, it would provide unrealistic results for the interference scenario constructed in this study. Instead, the knife-edge diffraction model in section 4.1 of Recommendation ITU-R P.526 is applied. Figure 3 below illustrates the geometry of diffraction loss between the IMT base station and the satellite due to the obstruction of the 25 m building. The results of the calculations indicate that the diffraction loss would be 21 dB.

FIGURE 3

Knife-edge diffraction model



Using the assumption of a 200 m micro urban cell radius, the number of base stations required to cover the New York City can be calculated. This information can then be compared against the US Census Bureau statistics to determine the number of base stations that are estimated to have a direct line-of-sight to the satellite as well as those for which the line-of-sight would be obstructed. These results have been shown in Table 1 below.

TABLE 1

Number of IMT base stations with and without LOS in New York

Area	**Population density per sq-mi**	**Area sq-km**	**No of BS**	**Buildings with 1-9 units (%)**	**No. of BS with LOS**	**Buildings with ≥ 10 units (%)**	**No. of BS without LOS**
New York City	27013	784	6030	47	2816	53	3214

The IMT and satellite system characteristics used in this study have been indicated in Section 1.1.

1.1. System characteristics used in the study

The characteristics of the IMT 5G networks operating in the 27.5-28.35 GHz band are indicated in Table 2 below together with the sources for the information. Two sets of parameters have been explored in order to study the interference from IMT deployments for various EIRP levels suggested by the IMT proponents. The first set uses the parameters proposed by the Commission in the “*NPRM*” in conjunction with parameters suggested in “*Straight Path's comments”*. The second set of parameters is explored to study the effects of increased base station EIRP limits which have been suggested by various IMT 5G proponents. The suggestions to increase the base station EIRP range from 10-23 dB in “*Straight Path’s comments*”[19], Qualcomm’s comments[20], TIA’s comments[21], “*Verizon’s comments”*[22] and “*Nokia's comments”*. The latter contribution is used to in this study, which promoted the use of a 23 dB higher EIRP level.

TABLE 2

Characteristics of the 27.5-28.35 GHz IMT system

Parameters			**Value Straight Path**	**Value Nokia**	**Comment**
Base Station	Deployment scenario		Micro urban		*“NYU Study”*
	EIRP	Max	62 dBm	85 dBm	*“NPRM”* *“Nokia’s comments” page 26*
		Avg.	60 dBm	82 dBm	*“Straight Path’s comments”* page A-1 (62.5% duty cycle) *“Nokia’s comments” page 26*
	EIPR power spectrum density (psd)	Max	62 dBm/100 MHz	85 dBm/100 MHz	*“NPRM”*
		Avg.	60 dBm/100 MHz	82 dBm/100 MHz	
	Max. antenna gain		27 dBi		*“Straight Path’s comments” page A-1*
	P.s.d. at antenna input	Max.	35 dBm/100 MHz	58 dBm/100 MHz	Calculated based on above
		Avg.	33 dBm/100 MHz	55 dBm/100 MHz	
	Antenna gain in the direction of the sky		6 dB		*“Straight Path’s comments”*page 34;B-1
	Density of simultaneously active stations		1 per 0.13 km^2		*“NYU Study”* (cell radius: 200 m)

Characteristics representing the Inmarsat’s Global Xpress I5-F2 satellite are shown in Table 3 below. However, it should be noted that the I5-F2 is just one example of a 28 GHz band satellite. There are existing satellites currently in operation that have higher spot beam antenna gains and lower satellite noise temperatures, which makes these satellite more susceptible to interference from IMT systems. Furthermore, additional planned Ka-band satellites have satellite noise temperatures that are in the order of 500 K.

19 *See page 40 in “Straight Path’s comments”*

20 Comments of Qualcomm Inc., GN Docket No. 14-177, RM-11664 (dated Jan 27, 2016), page 16

21 Comments of The Telecommunications Industry Association, GN Docket No. 14-177, RM-11664 (filed Jan 27, 2016), page 2

22 *See page 16 in “Verizon’s comments”*

TABLE 3

Representative characteristics of the Inmarsat I5-F2 satellite

Parameters	Value	Comment
Satellite noise temperature	1400 K	I5-F2 specification
Spot beam antenna gain	46 dBi	I5-F2 specification
Polarization	Circular	I5-F2 specification

1.2. Interference calculation

The permissible interference threshold for the satellite[23] is indicated in Table 4 below and calculations for interference resulting from deployment of IMT base stations (BS) in New York is indicated in Table 5 and Table 6 respectively.

TABLE 4

Permissible interference from IMT deployments into Inmarsat I5-F2 satellite

Parameter	Value
Centre frequency	28 350
Distance from satellite	37 855
Free space loss	213
Satellite noise temperature	31.4
Protection threshold	-12.2
Acceptable interference psd	-179
Satellite antenna gain	45.4
Polarization loss	3
Atmospheric absorption	1
Allowable IMT transmitting psd	-8

TABLE 5

Interference from IMT base station deployments in New York

IMT 27.5-28.35 GHz EMISSIONS		BS – Straight Path	BS – Nokia	
Psd at antenna input	Max.	-45 (35 dBm/100 MHz)	-22 (58 dBm/100 MHz)	dBm/Hz
	Avg.	-47 (33 dBm/100 MHz)	-25 (55 dBm/100 MHz)	dBm/Hz
Antenna gain in direction of sky		6		dBi
Interference eirp psd in direction of satellite	Max.	-39	-16	dBm/Hz
	Avg.	-41	-19	dBm/Hz
Target area size		784		km^2
Clutter loss in case of no LOS		21		dB
No. of simultaneously transmitting		With LOS: 2816		-

[23] Note that this should not be a guideline for future FCC interference analysis as there are GEO and non-GEO satellites currently in operation with different parameters (e.g. lower satellite receive system noise temperature, lower satellite altitude, higher satellite gain etc etc).

co-frequency stations/terminals in the target area	Without LOS: 3214		-
INTERFERENCE MARGIN			
Single base station margin (no clutter loss)	**31 dB**	**8 dB**	**dB**
Aggregate margin per target area	**-1.54**	**-26.5**	**dB**

The study indicates that a single IMT base station in the 27.5-28.35 GHz range is unlikely to cause interference, as the emissions would be well below the satellite's protection threshold. However, a complete IMT deployment in the 27.5-28.35 GHz band covering the city of New York is expected to result in excessive interference. More specifically, an IMT base station deployment covering the city of New York would exceed the satellite's protection margin by 1.54 dB when the EIRP levels in the "*NPRM"* have been used and by 26.5 dB when higher power levels are considered.

1.3. Aggregate interference over multiple IMT deployment areas

It should be noted that the territory of New York is only 0.1% of the whole area covered by the satellite's spot-beam. The aggregate interference from IMT deployments (both mobile and base station) in the whole area covered by the satellite's beam would significantly increase the interference to the satellite. The same beam that covers New York, would also include other densely populated cities such as Washington, Baltimore and Philadelphia, where similar IMT deployments are likely. Therefore, a further study is performed to consider the effects of interference from multiple areas containing IMT deployments that are covered by the satellite's beam.

The areas studied include the cities of New York, Washington, Baltimore and Philadelphia and the counties around the cities with a population density of more than 3800 people per square mile. The same methodology as specified in section 1 is used to determine the number of stations deployed in the area and the balance between stations that have a line-of-sight to the satellite and stations that do not. This information is indicated in Table 7 below.

TABLE 7

Number of IMT base stations with and without LOS in high-density areas within the satellite's beam[24]

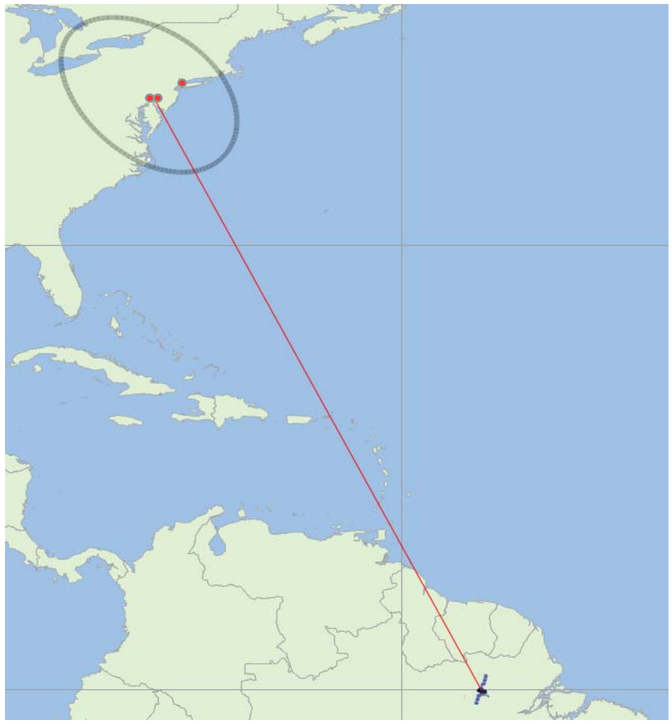
Area	Population density per sq mi	Area km^2	No of BS	Buildings with 1-9 units (%)	No. of BS with LOS	Buildings with ≥ 10 units (%)	No. of BS without LOS
New York City, NY	27013	784	6029	47	2816	53	3214
Nassau, NY	4705	737	5672	90	5117	10	556
Hudson, NJ	13731	120	920	65	598	35	322
Essex, NY	6212	327	2514	78	1949	23	566
Union, NY	5216	266	2049	85	1742	15	307
Bergen, NJ	3885	603	4642	82	3816	18	826
Washington, DC	9857	158	1215	55	664	45	552
Baltimore City, MD	7672	210	1613	84	1358	16	255
Alexandria, VA	9314	39	299	50	150	50	149
Philadelphia City, PA	11380	347	2670	86	2296	14	374
TOTAL		**3591**	**27625**	**722**	**20504**	**279**	**7121**

24 *Available from*: http://www.census.gov/

The coverage of the Inmarsat I5-F2 and the areas in Table 7 have been indicated in Figure 4 below.

FIGURE 4

Inmarsat I5-F2 spot-beam covering the target areas



The interference calculations for IMT base stations deployed in the areas covered in Table 7 is indicated in Table 8.

TABLE 8

Interference from IMT base station deployments in multiple areas within the satellite's beam

IMT 27.5-28.35 GHz EMISSIONS		**BS – Straight Path**	**BS – Nokia**	
Psd at antenna input	Avg.	-47 (33 dBm/100 MHz)	-25 (55 dBm/100 MHz)	dBm/Hz
Antenna gain in direction of sky		6		dBi
Interference eirp psd in direction of satellite	Avg.	-41	-19	dBm/Hz
Target area size		3591		km^2
Clutter loss in case of no LOS		21		dB
No. of simultaneously transmitting co-frequency stations/terminals in the target area		With LOS: 20 504		-
		Without LOS: 7121		-

INTERFERENCE MARGIN			
Aggregate margin per target area	**-9.8**	**-31.8**	**dB**

The study indicates that when multiple areas within the satellite's spot beam are considered for IMT deployment, the interference increases significantly. The total interference from IMT deployments in the cities of New York, Washington, Baltimore, Philadelphia and their surrounding densely populated counties result in the satellite's protection margin being exceeded by -9.8 dB in the case of *"NPRM"* EIRP levels and -31.8 in the case of suggested higher EIRP limits.

2. Conclusion

The study shows that sharing the 27.5-28.35 GHz frequency band between IMT 5G networks and satellite systems under the parameters proposed by the FCC could result in harmful interference to satellites. It is found that the aggregate interference from IMT base stations deployed in New York alone will exceed the interference threshold of an example Inmarsat's Global Xpress satellite by 1.34 dB. In respect of other more sensitive Ka-band GEO satellites, the aggregate interference from IMT base stations deployed in New York alone will exceed the interference threshold by 7 to 10 dB or more. The matter is even more concerning when interference from multiple densely populated cities and its surrounding areas within the satellite's spot-beam are taken into consideration. In that case, the study shows that for the example satellite considered the satellite's margin will be exceeded by 9.8 dB from the aggregated interference of multiple areas within the spot-beam. Further, "*Straight Path's comments*"[25] provide evidence on the potential of *mmW* frequencies to provide wide-area mobile broadband coverage in both urban and rural areas. The study considered the most densely populated cities, which are only about 0.5% of the whole coverage of the satellite's spot-beam. A wide-area deployment across the whole spot-beam would further increase the aggregate interference from base and mobile stations, which could threaten the operations of the satellite.

We note requests by IMT proponents to increase the base station EIRP limit suggested in the NPRM by 10-22 dB. The study shows that this would result in significant additional interference and for the example satellite considered the satellite's protection margin would be exceeded by 26.5 dB if interference from the City of New York is considered and by 31.8 dB if other densely populated areas within the satellite's spot-beam are considered. Further, *"Nokia's comments"*[26] suggest that downlink throughput of an outdoor base stations of 869 Mbps would remain unachievable without using 85 dBm/800 MHz (14 dB/Hz higher spectral density than suggested by the *"NPRM").* It can be therefore concluded that the full potential

25 *See section 3 in "Straight Path's comments"*

26*See page 8 of Appendix A in "Nokia's comments"* of IMT 5G networks in the 28 GHz range would not be achievable without interference to the satellite.

It should also be noted that assessing the amount of interference emitted towards the satellite from IMT deployments in the 28 GHz band is complicated due to the architecture and characteristics of the IMT system and the quasi-optical nature of the propagation of mmW radio waves. As noted in "*Straight Path's comments"*[27], mobile stations as well as small cell backhaul links can exhibit significant gain towards the sky, since they point upward to communicate with the higher micro/macro towers and due to antenna side lobes created by practical impairments of phase and amplitude errors of beamforming antennas. This combined with the notion that the down-tilt angle of the base stations cannot be relied upon, as the beams of the antennas follow the mobile terminals, make it increasingly difficult to assess the amount of IMT interference towards the satellite. In addition, the radio waves in the *mmW* frequency range have optical like qualities and even in areas where the line-of-sight to the satellite is blocked, street canyons can reflect the emissions so that a significant amount of energy will eventually be directed towards the satellite.

Therefore, as a minimum, the Commission should carefully study the interference to the satellite in the 28 GHz band before proceeding with the rulemaking. Based on our calculations, in order to reduce the potential interference to the satellite, the allowed spectral density in the 28 GHz range should be significantly lowered.

27*See page 34, 35 of "Straight Path's comments"*